MAGNETORESISTIVE RANDOM ACCESS MEMORY DEVICES AND METHODS OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. §119 to Korean Patent Application No. 10-2014-0091885, filed on Jul. 21, 2014, in the Korean Intellectual Property Office (KIPO), the contents of which are herein incorporated by reference in their entirety.

BACKGROUND

Example embodiments relate to semiconductor memory devices and methods of manufacturing the same. More particularly, example embodiments relate to magnetoresistive random access memory (MRAM) devices and methods of manufacturing the same.

An MRAM device may include a plurality of magnetic tunnel junction (MTJ) structures and bit lines electrically connected to the MTJ structures. Thus, methods of forming the MTJ structures and the bit lines with no damage caused thereto during fabrication may be needed.

SUMMARY

Example embodiments provide an MRAM device having no contact failures.

Example embodiments provide a method of manufacturing the MRAM device.

According to example embodiments, there is provided an MRAM device. The MRAM device may include a first insulating interlayer, a pattern structure, bit lines and an etch-stop layer. The first insulating interlayer comprises a flat first upper surface is formed on a first region and a second region of a substrate. A pattern structure comprising pillar-shaped magnetic tunnel junction (MTJ) structures and a filling layer pattern between the MTJ structures is formed on the first insulating interlayer of the first region. The pattern structure comprises a flat second upper surface that is higher than the first upper surface. The bit lines are formed on the pattern structure, and each of the bit lines contact top surfaces of the MTJ structures. The etch-stop layer is formed on the pattern structure between the bit lines of the first region and the first upper surface of the first insulating interlayer of the second region, and a first portion of an upper surface of the etch-stop layer on the first region is higher than a second portion of the upper surface of the etch-stop layer on the second region.

In example embodiments, the MRAM device may further comprise a capping layer pattern on a sidewall of each of the MTJ structures and the first insulating interlayer between the MTJ structures on the first region.

In example embodiments, the capping layer pattern may comprise silicon nitride or silicon oxynitride.

In example embodiments, the etch-stop layer may be formed on the entire first upper surface of the first insulating interlayer on the second region, a sidewall of the filling layer at an interface between the first and second regions, and a portion of an upper surface of the filling layer.

In example embodiments, the etch-stop layer may comprise silicon nitride, silicon oxynitride or aluminum oxide.

In example embodiments, the MRAM device may further comprise a second insulating interlayer on the etch-stop layer of the first and second regions, and the second insulating interlayer may fill gaps between the bit lines.

In example embodiments, a thickness of a portion of the second insulating interlayer on the first region is smaller than at thickness of a portion of the second insulating interlayer on the second region.

In example embodiments, a portion of an upper surface of the second insulating interlayer on the first region is substantially coplanar with a portion of the upper surface of the second insulating interlayer on the second region.

In example embodiments, the MRAM device is part of a computing device, such as, but not limited to, a personal digital assistant (PDA), a laptop computer, a mobile computer, a web tablet, a wireless phone, a cell phone, a smart phone, a digital music player, or a wireline or wireless electronic device. In example embodiments, the computing device comprises a touch-screen display.

In example embodiments, the MRAM device may further comprise a plurality of contact plugs extending through the first insulating interlayer, and the contact plugs may be electrically connected to the MTJ structures and the first region of the substrate.

In example embodiments, the MRAM device may further include a plurality of pad patterns in which a pad pattern is on a respective contact plug, and the pad patterns electrically connect the MTJ structures to the contact plugs, respectively.

According to example embodiments, there is provided an MRAM device. The MRAM device may comprise a lower structure, a plurality of magnetic tunnel junction (MTJ) structures, a capping layer pattern, a filling layer pattern, bit lines and an etch-stop layer. The lower structure comprising a flat first upper surface that is formed on a substrate. The MTJ structures comprise a pillar shape and are formed on the lower structure. The capping layer pattern is formed on a sidewall of each of the MTJ structures and the lower structure between the MTJ structures. The filling layer pattern is formed on the capping layer pattern, and the filling layer fills gaps between the MTJ structures, and a top surface of the filling layer is substantially coplanar with top surfaces of the MTJ structures. The bit lines are formed on the filling layer pattern and the MTJ structures, and each of the bit lines contacts the top surfaces of the MTJ structures. The etch-stop layer is formed on the filling layer pattern between the bit lines.

In example embodiments, the etch-stop layer may comprise a flat upper surface.

In example embodiments, the etch-stop layer may comprise silicon nitride, silicon oxynitride or aluminum oxide.

In example embodiments, the capping layer pattern may comprise silicon nitride or silicon oxynitride.

In example embodiments, the MRAM device may further comprise a second insulating interlayer on the etch-stop layer, and the second insulating interlayer may fill gaps between the bit lines.

In example embodiments, the MRAM device is part of a computing device, such as, but not limited to, a personal digital assistant (PDA), a laptop computer, a mobile computer, a web tablet, a wireless phone, a cell phone, a smart phone, a digital music player, or a wireline or wireless electronic device. In example embodiments, the computing device comprises a touch-screen display.

According to example embodiments, there is provided a method of manufacturing an MRAM device. In the method, a first insulating interlayer may be formed to have a flat first upper surface on a first region and a second region of a substrate. A pattern structure is formed on the first insulating